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OUTLOOK FOR THE ALASKA HERRING FISHERY IN 1948

by

L. N. Kolloen and C. H. Elling

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by

L. N. Kolloen and C. H. Elling, Aquatic Biologists
Branch of Fishery Biology

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INTRODUCTION

The Bureau of Fisheries and its successor agency, the Fish and Wildlife Service, have maintained a continuous study of the Alaska herring since 1925. The knowledge accumulated during these years is the basis of the present system of management which has for its goal the greatest annual production consistent with adequate survival of the stocks. A large step toward the achievement of this objective has been the development of a method of forecasting the abundance in advance of each fishing season, whereby the fishing intensity of each year can be kept in conformity with the changing abundance of the stocks.

The predictions of abundance, upon which the annual catch quotas have been set, have portrayed with fair accuracy the actual performance of the fishery in each succeeding year. Those published, for 1943[1], 1944[2], and 1947[3], were so well received that it appears apropos to publish a similar prediction for 1948, particularly in view of the changes in abundance that have taken, and still are taking, place.

Changes in abundance, or the total number within the stocks, results only when there is a change in the ratio of births to deaths. If the recruitment resulting from the entrance of new individuals into the stocks balances the losses through mortality, the abundance remains constant; if the recruitment exceeds the losses through mortality, the abundance increases; and if mortality exceeds recruitment, the abundance decreases. Because the rate of recruitment in the Alaska herring has been extremely variable and because the rate of mortality has fluctuated with the amount of fishing effort, great changes in abundance have characterized the fishery in the past.

METHOD USED IN FORECASTING ABUNDANCE

Ratios of Increment and Decrement

Forecasts of abundance require the knowledge of (1) the rate at which young fish are being added to the stocks and (2) the rate at which fish are being removed from the stocks. Observation, over a period of years, has shown that the number of herring in the catch at any age is, within limits, in fixed ratio to the number of that same year class which will enter the fishery in the following season. These ratios which are termed ratios of increment and decrement have provided fairly accurate estimates of the rate of recruitment and of the rate of mortality which has occurred under the fishing intensity of the past.

The rate at which a given brood will increase or decrease in available numbers with each increase in age has been obtained through a comparison of its percentage contribution to the catch of each successive year. Thus the percentage contribution of a given year class in its 4th year has been compared to its percentage contribution in its 3rd year; its percentage contribution in its 5th year to its percentage contribution

1/ Dahlgren, Edwin H. and Kolloen, Lawrence N. Outlook for the Alaska Herring Fishery in 1943. Fish and Wildlife Service, Fishery Leaflet 16. March 1943.

2/ Dahlgren, Edwin H. and Kolloen, Lawrence N. Outlook for the Alaska Herring Fishery in 1944. Fish and Wildlife Service, Special Scientific Report No. 25. March, 1944.

3/ Kolloen, Lawrence N. The Decline and Rehabilitation of the Southeastern Alaska Herring Fishery. Fish and Wildlife Service, Fishery Leaflet 252. July 1947.

in its 4th year; its percentage contribution in its 6th year to its percentage contribution in its 5th year, and so on, as long as it has remained in the fishery. Before these percentages were comparable, however, it was first necessary to weight each by the index of relative abundance (obtained from the return per unit of fishing effort) to account for the influence of changing abundance from year to year. By repeating these comparisons to include all year classes which have been represented in the fishery and by combining and averaging the ratios obtained with each increase of age, the average rate at which increment occurs during the first years in the life of the brood, and the average rate at which decrement occurs in its later years have been obtained.

Estimates of the Probable Yield of Each Year Class in the Coming Year

These ratios of increment and decrement provide the basis for estimating the number of individuals of any year class that will be available to the fishery in the coming year. Thus the number of 4-year fish can be estimated from the number present as 3-year fish in the preceding year by applying the established ratio of survival between the 3rd and 4th year. The number of 5-year fish can be estimated from the number present as 4-year fish in the preceding year by applying the established ratio of survival between the 4th and 5th years. In like manner the contribution of any year class can be estimated by applying the average rate of survival to the number of that same year class present in the catch of the preceding year. Of course this cannot include a measure of the abundance of fish entering the catch for the first time (3-year fish) so that the numbers at this age to be available in the coming year must be estimated from the average contribution of 3-year fish in the past, and considerable deviation from this average may be expected in any one year. However, as the entering year class represents only a small portion of the total numbers to be taken, this deficiency does not seriously lessen the accuracy of the predictions made by this method.

Estimates of the Total Potential Yield of Each Year Class

The ratios of increment and decrement are not only useful in estimating the probable contribution of each year class in the coming season but they also serve as a base for estimating the total potential yield of each year class to the fishery. These ratios when expressed in terms of percentage show what proportion of the total yield will be contributed at each age under the fishing effort of the past. Therefore, once a year class has entered the fishery its total potential yield can be readily measured from the numbers which have already been contributed at each age. This makes possible an evaluation of the relative numerical strength of each of the year classes within the fishery and furnishes information on the rate of recruitment taking place.

The measurement of the potential yield of each year class, however, cannot be made directly from its contributions to date because of the variation in the amount of fishing effort between years. To obtain comparable figures, on which to base such estimates, it is first necessary

to determine what the contributions would have been under conditions of equal fishing effort in all years. This is accomplished by taking the sum of the actual contributions for all past seasons and dividing by the sum of the abundance indices for the years involved which gives the average number of individuals taken per unit of fishing effort. This figure, when multiplied by the abundance index of each year, shows the number of individuals which would have been taken each year if the fishing effort had remained constant. The total number of individuals in each season's catch is then apportioned to each age according to the observed age composition of that particular year so as to obtain the total number that each year class would have contributed had the fishing intensity remained constant. Since these theoretical annual contributions are in terms of constant fishing effort, they can be used in ascertaining the potential yield of each of the year classes involved.

METHOD OF MANAGEMENT

This information on the magnitude of each of the year classes within the fishery and the total mortality that may be anticipated under varying levels of fishing effort is the present basis of management. Considerable stabilization of the yields has been achieved through the catch limitations in which fishing intensity is made to conform with changes in the rate of recruitment to the stocks. The quotas of each year are set to assure the survival of each year class to an age which will assure an adequate spawning stock, and will at the same time provide a reservoir of older fish to sustain the catch over those periods of poor survival of the spawn. Thus the size of the quota in each year will depend on the estimated total yield of each of the year classes within the fishery and the proportion of this yield that can be safely withdrawn in the coming year. The magnitude of the quota from year to year will thus reflect the change of abundance in the stocks.

This system of analysis has been applied to the Kodiak fishery since 1943 when ratios of survival were first established in that district. Similar abundance evaluations have been applied to the Southeastern Fishery for the past several years. Because fishing operations in the Prince William Sound district have been so erratic it has not been possible to make a comparable analysis of abundance for that district. The following paragraphs contain a review of the predictions that were made for Kodiak and Southeastern district for the season of 1947 together with the prospects in each of these districts for 1948. Also included is a discussion of probable abundance in the Prince William Sound district from such data as are available.

KODIAK

Review of Predictions for 1947

It was concluded from studies of abundance, based on the average ratios of increment and decrement, that the abundance would be relatively

high in this year. The principal reason for this conclusion was the presence of the dominant 1944 year class in its 4th year and the fact that the above-average year classes of 1942, 1941, and 1940 still remained available to the fishery. Although these year classes had already reached an age where the contribution declines with each succeeding year, their high potential yield still rendered them capable of making a large contribution to the catch of that year. The quota of 400,000 barrels reflected the estimate of the high abundance of the stocks.

That the abundance was at least as high as predicted was demonstrated by a catch of approximately 406,000 barrels made in this district during the season of 1947. Of this amount 387,000 barrels came from within the boundaries of the quota area. The magnitude of this catch is quite significant in view of the fact that fishing did not start until July 15th as a result of a delay in reaching satisfactory price and labor contracts. It is also significant that at the termination of fishing on October 15th herring were still highly available to the fishermen.

An index of abundance for the 1947 season was calculated by comparing the size of average delivery in each ten-day fishing period of the current season to the size of the average delivery in each comparable ten-day period of all former seasons. It will be observed from Table 1 that the 1947 index is one of the highest on record and is much higher than that of the preceding year. However, since there is reason to believe that the 1946 index was abnormally low because of factors affecting availability and did not truly reflect the abundance in that season, the change in abundance was probably not as marked as indicated by a comparison of the indices in the two successive years.

Table 1. -- Indices of Abundance in the Kodiak Herring Fishery for the Years 1937 to 1947 inclusive.

Year	Abundance Index in Terms of Average Poundage	Index Converted to the Relative Number of Individuals in which 1937 equals 100
1937	115.0	100.0
1938	124.4	113.5
1939	100.3	106.2
1940	97.1	94.6
1941	74.0	74.7
1942	84.5	97.7
1943	88.3	110.1
1944	94.3	113.5
1945	105.9	118.0
1946	86.8	88.2
1947	118.4	116.4

Because the indices of abundance as measured by the return per unit of fishing effort are known to be influenced by weather, behavior of

the fish, and by other factors affecting availability, they are not regarded as positive measures of abundance in any single year. However, since these factors of availability tend to be compensatory over a period of time, a trend established by these indices is considered representative of the long-range changes in abundance that have occurred. In an effort to discount these factors of availability a graph of abundance has been prepared which is based on the numerical strength of each of the year classes contributing to the fishery in the various years (Figure I). Each point on this graph represents the theoretical number of individuals which would have been available to the fishery under terms of constant fishing intensity and equal availability in each year. Basically it has been obtained by apportioning the estimated total yield of each year class to each fishing season according to the average percentage contribution at each age as obtained from the average ratios of increment and decrement with each increase in age.

The cause for the rise of abundance in 1947 over that of the preceding year was the attainment of its 4th year of life by the successful year class of 1944. This follows since, on the average, only 4.5 percent of the total yield of a year class is made in the 3rd year as compared to 18.4 percent in the 4th year. This year class contributed a total of 96 million individuals to the fishery in 1947 or approximately 31 percent of the total catch. The increment received from this year class plus that received from the 1945 class exceeded losses through mortality in the older year classes (past the 5th year) in which the percentage contributed diminishes with each increase of age.

Not only were the predictions of abundance confirmed by the success of fishing in 1947 but the predicted representation of each year class agreed closely with the actual age composition obtained through the sampling of the catch. A comparison of the predicted and actual age composition is shown in Table 2.

Table 2. — Comparison of Predicted and Actual Age Composition of the 1947 Catch of Kodiak Herring.

Age	Year Class	Predicted Percentage	Predicted Values Adjusted to Make Predicted and Actual Percentage of the Entering 1945 Year Class Equal	Actual
3-yr. fish	1945	4.4	2.2	2.2
4 " "	1944	32.2	32.9	30.7
5 " "	1943	14.0	14.3	10.7
6 " "	1942	14.7	15.0	13.8
7 " "	1941	17.4	17.8	16.2
8 " "	1940	12.3	12.6	19.2
9 " "	1939	4.9	5.0	4.9
10 " "	1938	.1	.1	.9

Ratios of Increment and Decrement

The average ratios of increment and decrement established for the period of 1937 through 1946, on which the prediction of age composition and of abundance for the 1947 season were based, have been revised to include the age composition data obtained in the past season. This revision shows that for the average brood there have been 4.1 fish in the catch in their 4th year for each one present in its third; 1.4 individuals in their 5th year for each one present in its 4th; 0.8 individuals in their 6th year for each one in its 5th; 0.8 individuals in their 7th for each one in its 6th; 0.7 individuals in their 8th year for each one present in its 7th; and that the established ratio of 0.5 individuals past age 8 surviving for each one which was present in the catch of the preceding season, has remained substantially the same.

The increment in available numbers as indicated by the ratio of 1 to 4.1 between the 3rd and 4th years and of 1 to 1.4 between the 4th and 5th years is explained by the fact that the members of any year class are not fully available to the fishery in their early years of life. It is apparent that only a small part of the total members enter the stocks from which the fishery makes its withdrawls in their third year, while the other members of that brood remain separated and unavailable as they were in their first and second years of life. Furthermore, only a part of the remainder of this brood enters the stocks which are available to the fishermen in the next (fourth) year, so that some remain to enter in their fifth year. The gain by the entry into the stocks of fish previously unavailable between their third and fifth years exceeds the losses by mortality at these ages, so that there is an actual gain in the numbers available to the fishery. Past the fifth year, however, mortality exceeds recruitment and the numbers available decrease at the rate indicated by the survival ratios established for each increase of age.

Predictions for the Season of 1948

Within the limits of accuracy of these established ratios of increment and decrement, it is possible to estimate not only the probable abundance and the age composition in the coming year, but also the size of yield that will result in a survival approximating that of the past years of the fishery.

As stated in the introduction to this paper, the determination of the proper yield in the coming season requires a knowledge of the numerical strength of each of the year classes that will contribute to the catch. These evaluations have been made from the number of individuals contributed by each year class in the past after adjusting to account for the variation in fishing effort from year to year. The estimates of the total production of each year class during its span in the fishery under the hypothetical condition of constant fishing intensity are shown in Table 3.

Table 3. — Number of Individuals Contributed by Each Year Class to the Kodiak Herring Fishery for the Years 1937-1947, Under Hypothetical Condition of Constant Fishing Effort.

Year Class	Exploited by the Fishery		Number Removed (In millions)	Potential Contribution (In millions)
	During Years	Years of Life		
1935	1937 - 1944	3rd - 10th incl.	119.4	Contribution Complete
1936	1938 - 1945	" " "	352.0	" "
1937	1939 - 1946	" " "	28.0	" "
1938	1940 - 1947	" " "	27.0	" "
1939	1941 - 1947	3rd - 9th "	262.2	267.3
1940	1942 - 1947	3rd - 8th "	292.3	314.0
1941	1943 - 1947	3rd - 7th "	212.9	256.8
1942	1944 - 1947	3rd - 6th "	110.4	163.1
1943	1945 - 1947	3rd - 5th "	48.7	101.0
1944	1946 - 1947	3rd - 4th "	78.3	341.9
1945	1947 Only	3rd Only	4.4	97.8

The potential contribution shown for those classes which have not yet completed their life span have been calculated on the basis of the average rate at which a year class will contribute its members under the fishing intensity exerted in the past. These estimates were obtained from the established ratios of increment and decrement and are, in reality, an expression of these ratios on a percentage basis. These estimates are contained in Table 4.

Table 4. -- Average Rate at Which a Year Class will Contribute its Members to the Kodiak Herring Fishery Under the Average Fishing Effort Expanded in the Period of 1937-1947 inclusive.

Age	Percentage of Total Yield Contributed at Each Age	Cumulative Percentage to Each Age
3rd Year	4.5	4.5
4th "	18.4	22.9
5th "	25.3	48.2
6th "	19.5	67.7
7th "	15.2	82.9
8th "	10.2	93.1
9th "	5.0	98.1
10th "	1.9	100.0

Under a fishing effort of average intensity which in the past has permitted survival to the 10th year, the average contribution of a brood in its third year will approximate 4.5 percent of its total contribution; the contribution of the 3rd and 4th years combined will approximate 22.9 percent; the contribution of the 3rd, 4th, and 5th years combined 48.2

percent; and so on, until by the time the brood has completed its 10th year no further significant contribution can be expected.

The contribution anticipated from each year class in the 1948 season, provided an average amount of effort be expended, has been determined by employing the average percentage of its total yield that will be made at the age attained in the coming year. These estimates are shown in Table 5.

Table 5. -- Year Classes in the Kodiak Herring Fishery, Their Total Potential Contribution, and Their Anticipated Contribution in 1948. (In millions of individuals)

Age in 1948	Year Class	Total Potential Contribution	Percent of Total Contribution to be Made in 1948	Number of Individuals to be Contributed	Percentage Age Composition
3rd Year	1946	Unknown	4.5	9.2	4.5
4th "	1945	97.8	18.4	18.0	8.8
5th "	1944	341.9	25.3	86.5	42.1
6th "	1943	101.0	19.5	19.7	9.6
7th "	1942	163.1	15.2	24.8	12.1
8th "	1941	256.8	10.2	26.2	12.8
9th "	1940	314.0	5.0	15.7	7.6
10th " and older	1939	267.3	1.9	5.1	2.5

The above contributions, when converted to barrels on the basis of the average weight at each age, demonstrate the optimum catch in 1948 to be 300,000 barrels. The quota for the coming season which has been set at this figure represents a 25 percent reduction from the quota of the 1947 season, and may appear somewhat contradictory in view of the successful season just concluded. When it is realized, however, that the recruitment from the entering 1945 year class was below average and that the year classes which have been largely responsible for the high abundance of recent years have been largely expended in the fishery, a reduction at this time is clearly justified.

The high abundance of recent years has been due to the presence of a series of successful year classes, particularly those of 1939, 1940, and 1941, which have made large contributions to the annual yields. These are now of an age, however, when the largest share (over 80%) of their total contributions have already been made so that their future contributions will be comparatively small. The loss accruing through the

decline of these older year classes has been compensated for, in part, by recruitment from the dominant year class of 1944 which entered the fishery as 3-year fish in 1946, contributed heavily as 4-year fish in 1947, and which may be expected to sustain the abundance as 5-year fish in 1948. However, this year class alone cannot maintain the present level of abundance for long without aid from the entrance of other successful year classes into the catch. From its contribution of 3-year fish in the 1947 season, the 1945 year class has been evaluated at 98 million individuals which is less than the average strength of entering year classes of the past. Under these circumstances the main support of the fishery for the next several years will be the year class of 1944. Under a catch quota of the same magnitude as for 1947 there would be an excessive withdrawl from this year class which will be in its 5th year in 1948, or at the age when its members are most available to the fishery. The early exhaustion of the 1944 year class before adequate replacement occurs through the entry of new successful year classes into the fishery would soon result in a reduced abundance of the stocks. A catch in excess of 300,000 barrels in 1948 could be made only at the expense of the available supply of future years.

SOUTHEASTERN

Review of Predictions for 1947

The predictions for the Southeastern fishery in 1947 were made from the ratios of increment and decrement with each increase of age occurring within the fishery in the years of 1929 through 1946. The prediction of increased abundance was based chiefly on the anticipation of a large contribution of 4-year fish from the dominant year class of 1944 and from a large contribution of 6-year fish from the successful year class of 1942. The established quota of 350,000 barrels was obtained from the sum of the optimum contributions of the year classes within the fishery.

The abundance, as reflected in the success of fishing during the season, was apparently less than that which had been anticipated. A catch of approximately 335,000 barrels was taken, however, despite a late start (July 15th) and despite very poor catches during the entire month of August. In early September large concentrations of herring appeared on the Cape Ommaney fishing grounds, but because weather seriously interfered with fishing operations throughout this month, it is believed that the catches made did not reflect the real abundance.

The small size of the individual catches in 1947 resulted in an index of abundance which was lower than that of the preceding year and the lowest on record since the reopening of the fishery in 1943. The indices for all years for which data are available are shown in Table 6.

Table 6. -- Indices of Abundance in the Southeastern Alaska Herring Fishery for the Years 1929 to 1947 inclusive.

Year	Abundance Index in Terms of Average Poundage	Index Converted to the Relative Number of Individuals in Which Base Year of 1932 Equals 100
1929	84.4	72.3
1930	76.0	58.6
1931	98.0	71.3
1932	138.9	100.0
1933	104.1	70.4
1934	89.1	72.1
1935	75.4	55.6
1936	76.3	55.3
1937	75.8	69.1
1938	48.3	41.8
1939	--- Not available	1/ ----
1940	--- " "	2/ ----
1941	--- " "	3/ ----
1942	--- " "	4/ ----
1943	118.1	101.8
1944	118.1	93.8
1945	129.9	103.9
1946	137.7	116.0
1947	115.1	91.4

1/ Cape Ommaney area closed
2/ Experimental operation; no catch made
3/ Experimental operation; with restriction on Cape Ommaney area
4/ District closed

As has been stated frequently the abundance index of any one year may be affected by changing availability, and may not therefore, show the true abundance in that year. There is reason to believe that the index as shown for 1947 is abnormally low and that the abundance has not seriously declined from that of the preceding year. This assumption is supported by the estimates of theoretical abundance which have been obtained by apportioning the total potential yield of each year class to each season according to the average percentage of its total yield that will be contributed at each age as determined from the ratios of increment and decrement prevailing in this fishery. The theoretical abundance is shown in Figure II in which each point represents the number of individuals which would have been available to the fishery under terms of constant fishing intensity and equal availability in each year.

The abundance of recent years, while exceptionally high, is probably less than indicated on the preceding graph. A large number of fishing

vessels operated in the period of 1930 to 1939 as compared to relatively few vessels in the period of 1943 through 1947. For this reason the indices of abundance based on the return per unit of effort are not directly comparable between these periods. No satisfactory method of weighting to account for this factor has been found, and the effect of the high indices of recent years obtained under low fishing intensity has been to exaggerate the potential yield of those year classes now within the fishery.

The sharp rise in the theoretical abundance in 1947 was due principally to the maturing of the 1944 year class into its 4th year, since it is at this age that the largest contribution to the fishery is made. Providing the evaluation of the total potential yield of this year class (from its contribution as 3-year fish) has been substantially correct the abundance in the 1947 season was unquestionably high and the apparent anomaly of a reduced index (based on the return per unit of effort) can only be attributed to low availability.

The age composition which had been predicted for the 1947 season on the basis of the average ratios of increment and decrement and those actually obtained by sampling the catch were remarkably close. The predicted and actual figures are shown in Table 7.

Table 7. -- Comparison of Predicted and Actual Age Composition of the 1947 Catch of Southeast Alaska Herring

Age	Year Class	Predicted Percentage	Predicted Values Adjusted to Make Predicted & Actual Percentage of the Entering 1945 Year Class Equal	Actual
3-yr. fish	1945	8.7	3.7	3.7
4 " "	1944	69.9	73.7	67.3
5 " "	1943	6.4	6.8	12.8
6 " "	1942	10.7	11.3	12.3
7 " "	1941	2.1	2.2	2.0
8 " "	1940	2.0	2.1	1.2
9 " "	1939	.2	.2	.2

As was predicted, the fishery was supported principally by the year class of 1944, with material assistance from the year classes of 1943 and 1942. The year class of 1945 entering the fishery for the first time in its third year contributed only 3.7 percent as compared to an average contribution of 8.7 percent made by all entering year classes in the past.

Ratios of Increment and Decrement

Since the average ratios of increment and decrement established for all past years are employed in establishing the probable abundance and the optimum yield in the coming year, they have been revised to include the age composition of the 1947 season. They show that under the fishing

intensity of the past there have been for the average brood 4.1 fish in the catch in their 4th year for each one present in its third; 0.7 in their 5th year for each one present in its 4th; 0.5 in their 6th year for each one present in its 5th; 0.5 in their 7th year for each one present in its 6th; 0.4 in their 8th year for each one present in its 7th; and that past the 8th year there have been 0.2 individuals surviving for each one present in the catch of the preceding year.

The above ratios of increment and decrement which show the average rate at which a year class will contribute its members to the fishery under the fishing intensity of the past are expressed on a percentage basis in Table 8.

Table 8. -- Average Rate at Which a Year Class will Contribute Its Members to the Southeast Alaska Herring Fishery Under the Average Fishing Effort Expended in the Period of 1929-1947 inclusive.

Age	Percentage of Total Yield Contributed at Each Age	Cumulative Percentage to Each Age
3rd Year	9.6	9.6
4th "	39.4	49.0
5th "	26.4	75.4
6th "	14.3	89.7
7th "	6.6	96.3
8th "	2.8	99.1
9th "	0.7	99.8
10th "	0.2	100.0

Predictions for the Season of 1948

The average rate of mortality for all past years provides a base for estimating not only the probable abundance and age composition in the coming season but also the amount of yield that will permit a survival approximating that which has prevailed in the past. The validity of such predictions will depend on the accuracy of the mortality estimates which are in turn governed by the accuracy with which the data reflects (1) the true percentage age composition of the stocks and (2) the true changes in abundance level.

Since the abundance is governed by the numerical strength of the year classes, predictions of abundance require an estimate of the total potential yield of each of those year classes contributing to the fishery. The total potential yield of each of the year classes which have contributed to the fishery has been calculated from the rate at which the average year class will contribute its members to the fishery (Table 8.). The total yields of those year classes which have already completed their full contribution to the fishery and the estimated total yields of those which have not as yet completed their life spans are shown in Table 9.

Table 9. -- Number of Individuals Contributed by Each Year Class to the Southeast Alaska Herring Fishery for the Period 1929-1947, Under the Hypothetical Condition of Constant Fishing Effort.

Year Class	Exploited by the Fishery		Number Removed (In millions)	Potential Contribution (In millions)
	During Years	Years of Life		
1927	1929 - 1936	3rd - 10th incl.	207.3	Contribution complete
1928	1930 - 1937	" " "	66.7	" "
1929	1931 - 1938	" " "	246.3	" "
1930	1932 - 1939	" " "	61.2	" "
1931	1933 - 1940	" " "	524.5	" "
1932	1934 - 1941	" " "	35.4	" "
1933	1935 - 1942	" " "	56.5	" "
1934	1936 - 1943	" " "	84.2	" "
1935	1937 - 1944	" " "	366.5	" "
1936	1938 - 1945	" " "	240.6	" "
1937	1939 - 1946	" " "	97.1	" "
1938	1940 - 1947	" " "	76.8	" "
1939	1941 - 1947	3rd - 9th "	200.2	200.6 "
1940	1942 - 1947	3rd - 8th "	460.0	464.1
1941	1943 - 1947	3rd - 7th "	205.6	213.5
1942	1944 - 1947	3rd - 6th "	448.2	499.7
1943	1945 - 1947	3rd - 5th "	127.0	168.4
1944	1946 - 1947	3rd - 4th	303.4	619.2
1945	1947 Only	3rd Only	10.9	113.5

The contribution anticipated from each year class in the 1948 season, provided an average amount of fishing effort be expended, has been determined by employing the average percentage of its total yield that will be made at the age attained in the coming year. These estimates are shown in Table 10.

Table 101 -- Year Classes in the Sitka Herring Population of Southeast Alaska, Their Total Potential Contribution, and Their Anticipated Contribution in 1948. (In millions of individuals).

Age in 1948	Year Class	Total Potential Contribution	Percent of Total Contribution to be made in 1948	Number of Individuals to be Contributed	Percentage Age Composition
3rd Year	1946	Unknown	9.6 1/	29.2	9.6 1/
4th "	1945	113.5	39.4	44.7	14.7
5th "	1944	619.2	26.4	163.5	53.8
6th "	1943	168.4	14.3	24.1	7.9
7th "	1942	499.7	6.6	33.0	10.9
8th "	1941	213.5	2.8	6.0	2.0
9th " and older	1940	464.1	.9	3.6	1.1

1/ Average of the percentage contributions made by the entering year classes in the past 19 years.

To obtain the optimum yield of the Sitka stock in the season of 1948, the yield of each year class in individuals has been converted to barrels by using the average weight at each age. The figure thus obtained is approximately 300,000 barrels. Since the Sitka population has produced over 70 percent of the total yield in the Southeastern fishery, it is necessarily the governing factor in establishing the proper catch for this district as a whole. Other populations (principally those of Craig and Juneau) have contributed, on the average, 30 percent of each years catch and assuming that they will produce in like proportion in the coming season, an additional 100,000 barrels can be anticipated from this source. Thus the optimum yield for the entire fishery becomes 400,000 barrels which is the established quota in the coming year.

That this quota is greater than that established for the Kodiak district is explained by the fact that the year classes now within the Southeastern fishery are of greater numerical strength than those of the former area. For example the 1944 year class which is dominant in both areas has an appraised potential yield of 619 million individuals in Southeastern as compared to 342 million at Kodiak. Similarly all of the year classes in the Southeastern fishery, with the exception of that of 1941, have been estimated to have greater potential yields than the same year classes in the Kodiak fishery. However, besides a higher potential yield, the rate of mortality is also greater, so that these year classes are available to the fishery for a lesser period of years, and for which reason the Southeastern fishery is more subject to sharp fluctuations in the annual yields.

With a catch of 400,000 barrels in the coming season those year classes now within the fishery should survive in significant numbers through their 8th year since the quota will in effect limit the fishing intensity to an average of that exerted in past years. Abundance will be high because of the presence of the dominant year class of 1944 in its 5th year and the presence of the successful year class of 1942 in its 7th year. The present high level of abundance cannot be maintained in future years, however, without significant recruitment through the entrance of successful year classes into the catch.

PRINCE WILLIAM SOUND

Summary of Operations Since 1941

Except for confirming the fact that the abundance of the stocks has been at a very low level, the irregular operation of this fishery during the past six years has provided very little information on which to base predictions of abundance. Under the low abundance and under the regulations invoked by the Service to rebuild these populations there has been no full scale operation in this district since 1941. Such operations as have been conducted have been chiefly experimental in character and of such small scale that the catches obtained were of slight value as measures of abundance. In the last four years the vessels engaged in the fishery have not remained for the fall period and consequently there are no data available for that portion of the season in those years. In two years (1943 and 1947) there were no operations in this district and the catches which were made were taken by Kodiak vessels fishing in this area. The operations since 1941 are summeraized in Table 11.

Table 11. -- Summary of Operations in the Prince William Sound Herring Fishery in the Years 1941 Through 1947.

Year	No. Plants	No. of Vessels	Catch		Established Quota	
			Summer	Fall	Summer	Fall
1941	6	29	212,641	47,087	250,000	
1942	1 1/	6	6,310	6,086	25,000	50,000
1943	1	4	21,848 2/	8,008	25,000	50,000
1944	1 3/	5	59,981	None	75,000	125,000
1945	2	8	25,090	None	150,000	Unlimited
1946	2	8	26,563	None	150,000	Unlimited
1947	None	None	13,663 2/	None	150,000	Unlimited

1/ Consolidated operation by four companies
2/ Catch made by Kodiak boats and delivered to Kodiak plants
3/ Joint operation by two companies

These operations have proved inadequate for the measurement of abundance because they have not provided sufficient data for the determination of the return per unit of effort (abundance index)nor have they provided an uninterrupted series of age composition data on which to establish the average ratios of increment and decrement with each increase of age. As already stated information on the relative abundance and the rate of mortality both are necessary before estimates of the total potential contribution of each of the several year classes, and their optimum yields in the coming year, can be made accurately. Lacking these data it is not possible to make specific predictions as was done for the Kodiak and Southeastern districts. However, an effort has been made to appraise the relative importance of the year classes contributing to the Prince William Sound fishery and to forecast their probable influence on the success of fishing in the coming year.

Summer and Fall Runs

Predictions in the fishery are further complicated by a division of the fishery into the summer and fall periods with the fishing success of each being governed by the occurance of the so called "summer" and "fall" runs. The summer run is available in greatest abundance from the opening of the season (June 15th) until about mid-July while the fall run, when present, begins in late August and continues throughout the fall period. A distinct period of slack fishing marks the interval between these runs.

Age composition data have established that the summer run is composed largely of the younger individuals, i.e., of 3- to 5-year and infrequently of 6-year fish, while the fall run is composed of individuals of age six and older. The existence of the two runs is attributed to a differential schooling of a common stock of fish, with the younger individuals being more available in the summer, and the older individuals being more available in the fall.

In Prince William Sound as in the other areas of Alaska, the spawnings have met with varied success, some producing in abundance while others have been almost total failures. Years of high abundance have reflected the presence of one or more successful year classes within the stocks. In years in which such classes have been young, (ages 3-5) and so present in the summer fishery, they have increased the abundance in that period, while in years in which they have been older (6th year and above), they have increased the abundance in the fall period. Such year classes have served to sustain the abundance until such time as they were reduced in number by imposed and natural mortality.

History of the Fishery in Recent Years

Season of 1941

The lowered abundance in this area became apparent with the relatively small catch of 47,000 barrels in the fall period of this year. This failure indicated that the successful year classes of 1935 and 1936 which had

largely supported the fishery in the three previous years had become so reduced that they could no longer provide significant yields. In 1941 these year classes were in their 7th and 6th years respectively or at an age when the main contribution is made during the fall period. Their failure to appear in significant numbers was attributed to excessive removals in the summer fishery of 1937 through 1940 when they were young and therefore most available in the summer period. Another situation which reflected unfavorably on future abundance was the dependence of the summer fishery on the year class of 1939 which contributed 47 percent of the summer's catch as 3-year fish. While such a contribution demonstrated that this year class was quite successful it also became apparent that under such a high rate of removal its members would probably not survive to a sufficient age to bolster abundance in the fall period in later years.

Season of 1942

Because eventual restoration of the fall fishery would require protection of the younger age groups in the summer period the quota of the 1942 season was divided between the summer and fall seasons. The summer quota was established at 25,000 barrels for the purpose of protecting the 1939 year class as 4-year fish and the incoming year class of 1940 as 3-year fish. The quota for the fall period was established at 50,000 barrels.

Under these regulations the companies consolidated their operations at one plant employing six vessels. While the delay in the start of operations until the peak of the summer run had already passed was partly responsible for the low catch (6300 bbls) in the summer period, it was due mainly to low abundance of the summer run. This indicated that the 1939 year class had been reduced seriously in numbers by the excessive removal of 3-year fish in the preceding year and that its capacity to contribute in future years probably had been impared. The fall catch of only 12,000 barrels, comprised of 53 percent of 3-year fish of the year class of 1939, demonstrated that the older year classes had been expended completely and were no longer available to the fishery.

Season of 1943

Because of the apparent low abundance, the same quotas of the preceding year, 25,000 barrels in the summer and 50,000 barrels in the fall, were applied to this district in 1943. Only one company, employing only two vessels, engaged in this fishery for two weeks in September. The 22,000 barrel catch of the summer period was taken by the Kodiak fishing fleet between the 3rd and 15th of July. The bulk of the summer catch was again made from the 1939 year class which was then in its 5th year. The relatively high returns during this short period of operation restored hope that the 1939 year class was not in such a depleted condition as indicated by the poor catch of the preceding year. The fall fishing was again disappointing and gave further evidence that there were no longer significant year classes available to support the fishery in this period.

Season of 1944

The quotas in this year were increased in anticipation that the 1940, 1941, and 1942 year classes would support a larger catch in the summer fishery as 5-, 4-, and 3-year fish, and that the 1939 year class which was then in its 6th year would be able to make a significant contribution to the fall run. The companies again consolidated in a joint operation and the five vessels employed caught 60,000 barrels during the summer period. The fact that 54 percent of this catch was made from the year class of 1942 coupled with a relatively high return per unit of fishing effort gave promise that it might be a successful year class and that its entry into the fishery might restore the abundance of the summer period. The 1939 year class which had reached its 6th year would normally contribute to the fall fishery, but the failure of the fall run to appear by September 12 was interpreted to mean that the 1939 year class had become so debilitated by its contributions to the summer period of previous years that it was no longer sufficiently numerous to support a fall run.

Season of 1945

The quota for the summer period in the season of 1945 was increased to 150,000 barrels on the basis of fair abundance in this period during 1944 and on the strong appearance of the year class of 1942. Since no real estimate of the remaining capacity of the 1939 year class could be made and the size of the fall operations in the district are more or less governed by the size of the summer fishery, no catch limit was placed on the fall fishery.

The operators again consolidated their efforts in the operation of two plants with a combined fleet of eight vessels. The failure to take more than 25,000 barrels within the Sound during the summer period was attributed mainly to low availability rather than to a scarcity of fish. Although the fishermen continued to search until mid-September, no fish were found in the fall period, which served to corroborate the conclusion previously reached that the 1939 year class had become so depleted that it was no longer a significant factor in the fishery.

Season of 1946

The 1946 regulations remained the same as those in effect in 1945 with the intent that the fishing intensity should remain low until such time as it clearly was shown that an increase in abundance had occurred. Fair abundance during the summer period was anticipated from the fact that the fishery had been operating on a reduced level over the past several years and had not, therefore, made any large withdrawals from the year classes of 1943 and 1942 which would be expected to contribute as 4-year and 5-year fish, respectively, in 1946. With no background knowledge of the year classes remaining in the populations there was no base on which to evaluate the probable magnitude of the fall run and, for this reason, no quota limitation was placed on the fall period.

Two plants with a combined fleet of eight vessels made a catch of 103,000 barrels of which 77,000 were taken from the Resurrection Bay area and 25,000 were taken from within the Sound. During the short period of availability (two weeks)the catches composed mainly of 3-year fish of the entering year class of 1944 were large, indicating a high abundance in this period. Because the fall fish had failed to appear by September 1st operations were suspended on that date, so that there was not an adequate test of the presence of a fall run in this year.

Season of 1947

The outlook for the summer fishery in 1947 appeared favorable because of sizable contributions anticipated from the year classes of 1944 and 1943 as 4-year and 5-year fish respectively. The possibility of a fall run was supported by the maturing of the 1942 year class into its sixth year when it could be expected to contribute mainly in the fall period. Because of difficulties encountered in negotiating labor and fishing contracts no operations were conducted in the Prince William Sound district during 1947 so that no information on the year classes present or on their abundance was obtained in that year.

Relation of the Resurrection Bay Fishery to that of Prince William Sound

A development resulting from the lowered abundance within Prince William Sound has been the expansion of the fishery into the adjacent area of Resurrection Bay. The exploitation of this area, first begun in 1941 by the Prince William Sound fleet, has been continued in most years following by both the Prince William Sound and Kodiak boats. The dependence of the Prince William Sound operations upon the Resurrection Bay catch is shown in Table 12.

Table 12. -- Catch in 250 Pound Barrels of Herring in Resurrection Bay by the Prince William Sound and Kodiak Fishing Fleets.

Year	Catch		Total Catch
	By P.W.S. boats	By Kodiak boats	
1937	327	-----	327
1938	----	-----	-----
1939	720	-----	720
1940	----	-----	-----
1941	12,622	-----	12,622
1942	1,497	-----	1,497
1943	----	20,804	20,804
1944	23,984	103,514	127,498
1945	54,782	62,144	116,926
1946	76,906	59,214	136,120
1947	----	4,180	4,180

The recent erratic behavior of the Prince William Sound summer fishery, together with the increase of catch in Resurrection Bay, has raised the question as to whether or not the two areas (approximately 45 miles apart) are supported by a common stock. It has been observed that when herring are not available within the Sound they are frequently available in Resurrection Bay, and that when the members of a particular year class fail to contribute in anticipated percentage to the catch within the Sound, they frequently constitute a large proportion of the catch in Resurrection Bay.

Since there have not been sufficient funds for a tagging program the relationship of the populations in these several areas has not been clearly defined. The shift of the fishery in recent years and the inconsistent appearance of herring within the Sound has been assumed to be due to a common stock which shifts its feeding migration between the two areas. It is also considered probable that this stock may be joined by the populations of other areas on the common Resurrection Bay feeding grounds in a situation comparable to that existing in the Tebenkof area of southeastern Alaska where that area is jointly occupied by portions of both the Craig and Sitka stocks.

Because of the low abundance of the Prince William Sound stocks and the apparent danger of their being over-fished on the Resurrection Bay grounds, a common quota was established for these two areas in the season of 1947. This provided that catches made in either area would be charged against a common quota of 150,000 barrels established for the summer period. This regulation which is also effective for 1948 should insure adequate protection for the younger age groups which are most available in the summer period and upon which the ultimate rehabilitation of the fishery must depend.

Prospects for the Fishery in 1948

Lacking regular operations over the past five years there are very few data on which to predict the abundance in either the summer or the fall period in the coming year. It is possible, however, to determine the year classes now available and from the present age of each to ascertain in what portion of the season they may be expected to contribute in largest degree. While it is impossible to evaluate the total potential yield of each as has been accomplished in the other districts by establishing ratios of increment and decrement, some concept of their importance may be obtained from this evaluation in the other major fishing areas. Experience has shown that the success of spawning follows a somewhat similar pattern in each of the larger fishing areas. The year classes available and their relative importance in the Kodiak and Southeastern districts are shown in Table 13.

Table 13. -- The Year Classes of Herring Available in the Kodiak and Southeastern Districts and their Relative Importance.

Year Class	Age in 1948	Southeastern	Kodiak
1946	3rd Year	Unknown	Unknown
1945	4th "	Below Average	Below Average
1944	5th "	Highly Successful	Highly Successful
1943	6th "	Average	Below Average
1942	7th "	Highly Successful	Average
1941	8th "	Average	Successful
1940	9th "	Highly Successful	Highly Successful

If the relative success of the various year classes in Prince William Sound has followed a pattern similar to that of the other districts, there would appear to be three successful year classes available to the fishery which would bolster the prospects for a successful season in 1948. However, in view of the poor performance of the fishery in recent years this conclusion cannot be accepted without closer examination of the histories of each of the year classes concerned.

Summer Fishery

Since the summer fishery draws principally from the age groups of three to five, it will be supported mainly by the year classes of 1946, 1945, and 1944. The 1946 year class will enter the fishery in its third year for the first time in the coming season so that there is no basis for judging its probable contribution. Because there was no operation in this district in 1947, there is likewise no information on the year class of 1945 which entered the fishery for the first time in that year, and which will contribute to the fishery in 1948 as 4-year fish. The only grounds for the appraisal of this year class is its contribution of 3-year fish to the Southeastern and Kodiak fisheries. In each of these districts its contribution was below average and it is unlikely that it was more successful in Prince William Sound. The only record of the 1944 year class is from its contribution as 3-year fish in the season of 1946. The fact that it represented 72 percent of the catch combined with the fact that large catches were made during the short period in which herring were available within the Sound in that season indicates a fair abundance for this brood.

It is concluded that the success of the summer fishery will depend primarily on the present status of the year class of 1944. If its numerical strength in the Prince William Sound fishery is comparable to that exhibited in the other fishing districts there is good reason to believe that the abundance will be high. Since there have been virtually no withdrawls against it during its 3rd and 4th years, it should be able to provide good catches during the summer period of 1948.

Fall Fishery

The fall fishery which is supported mainly by those age groups of six years and older will be drawing from the year classes of 1943, 1942, 1941, and 1940 as 6-, 7-, 8-, and 9-year fish respectively. As measured in the Southeastern and Kodiak fisheries only one (1943) has been classified as below average, one (1941) as average, and two (1942 and 1940) as above average in total potential yield. If a positive correlation exists between the success of spawning in the various fishing districts as has been indicated by the records of the past, these year classes should be of sufficient strength to support a fair fall run.

Of the year classes assumed to be of above average strength only that of 1942 can be expected to make a significant contribution to the fishery since the 1940 year class will have attained an age (ninth year) when its numbers will have been severely reduced through natural and imposed mortality. The 1942 year class comprised 54 percent of the summer's catch of 1944 as 3-year fish, 46 percent of the summer's catch of 1945 as 4-year fish, and 11 percent of the summer's catch of 1946 as 5-year fish. It will be in its 7th year in 1948 and should still remain sufficiently abundant to make a sizable contribution to the fall fishery of 1948. In addition, there should be some 8-year fish available from the year class of 1941. If these two year classes compare in total numbers to their appraised strength in each of the other fishing districts there is good reason to anticipate a fair fall catch in 1948 provided that the plants operate and provided that the fishermen remain until the closing date of October 15th.

It appears probable because of low fishing intensity against these stocks in recent years that there has been sufficient survival to have partially restored the abundance in this area. It is also probable that the series of successful year classes which have bolstered abundance in the other fishing districts have also entered these populations; under these circumstances the prospects for a successful operation in this district in 1948 appear good.

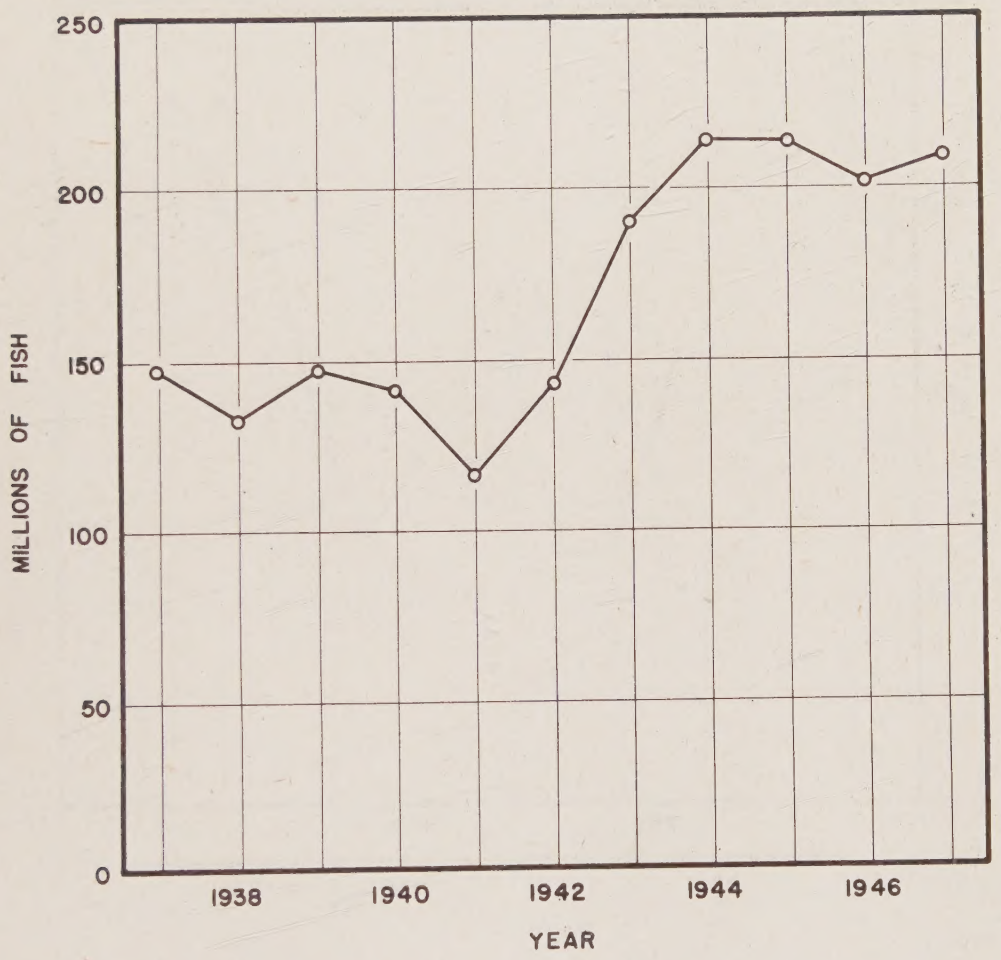

Figure I. The Theoretical Abundance of Kodiak Herring for the Years 1937-1947 inclusive

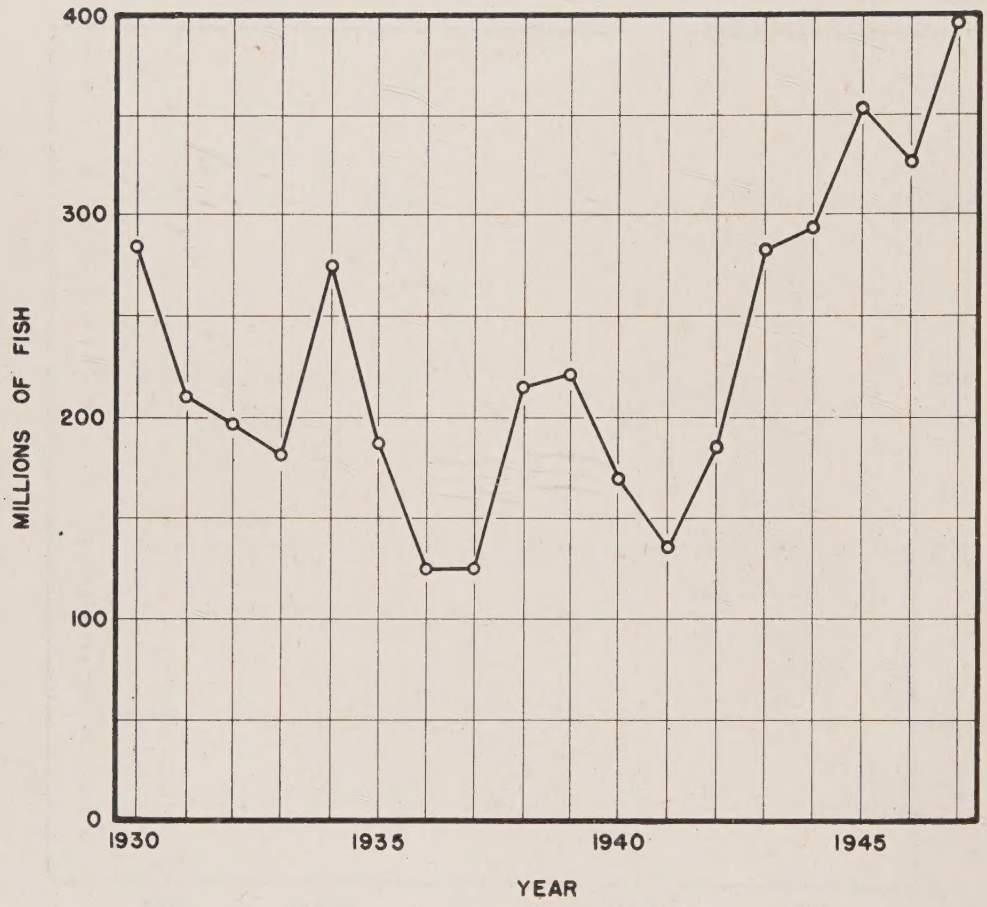

Figure II. The Theoretical Abundance of Sitka Herring Stock of Southeastern Alaska for the Years 1930-1947 inclusive.